PLANT ITEM MATERIAL SELECTION DATA SHEET

R10672008

LOP-SCB-00001 & LOP-SCB-00002 (LAW)
Melter 1 and Melter 2 Submerged Bed Scrubbers (SBS)

- Design Temperature (°F)(max/min): 237/41
- Design Pressure (psig) (max/min): 15/FV
- Location: process cell

ISSUED BY
RPP-WTP PDC

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Operating conditions are as stated on attached Process Corrosion Data Sheet

Operating Modes Considered:

- Normal operation at pH 3 at the normal operating temperature
- Normal operation at pH 8 at the normal operating temperature
- Vessel is at pH 3 and the temperature reaches 167°F due to loss of cooling jacket function

Materials Considered:

Material (UNS No.)	Relative Cost	Acceptable Material	Unacceptable Material
Carbon Steel	0.23		X
304L (S30403)	1.00		X
316L (S31603)	1.18		X
6% Mo (N08367/N08926)	7.64		X
Alloy 22 (N06022)	11.4	X	
Ti-2 (R50400)	10.1		X

Recommended Material: Hastelloy C-22 or the equivalent; packing is a ceramic

Recommended Corrosion Allowance: 0.040 inch (includes 0.024 inch corrosion allowance and 0.004 inch erosion allowance)

Process & Operations Limitations:

- Develop lay-up strategy

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This bound document contains a total of 7 sheets.

REV	DATE	REASON FOR REVISION	PREPARER	CHECKER	APPROVER
1	4/18/06	Issued for Permitting Use	DLA	JRD	APR
0	1/27/04	Issued for Permitting Use	DLA	JRD	APR

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Corrosion Considerations:

Offgas from the film cooler at a nominal temperature of 572 °F is directed into the SBS column vessel for cooling and solids removal. A cooling jacket located on the outside of the scrubber vessel maintains the required temperatures. Loss of cooling jacket function could allow the solution temperature to rise as high as 167 °F.

a General Corrosion
Wilding and Paige (1976) have shown that in 5% nitric acid with 1000 ppm fluoride at 290°F, the corrosion rate of 304L can be kept as low as 5 mpy by the use of Al^{+++}. Additionally, Sedriks (1996) has noted with 10% (≈2N) nitric acid and 3,000 ppm fluoride at 158°F, the corrosion rate of 304L is over 4,000 mpy; C-22 has a corrosion rate of about 75 mpy. While the anticipated pH in this case is higher, there are regions in the system where the pH is low or where there could be excess fluoride without the presence of aluminum. Consequently, corrosion resistant alloys such as Hastelloy C-22 will be required.

The dissolution rate of the ceramic components in the proposed environment is unknown. However, data from Clark and Zoitos (1992) suggest Al_2O_3, SiC, and ZrO_2 ceramics will have little reactivity in the proposed solutions. The effect of fluoride and the varying temperatures is unclear but the uniform corrosion rate is expected to be larger.

Conclusion:
Hastelloy C-22 or the equivalent is recommended to protect the regions in the scrubber that are exposed to excessive temperatures and concentrations. A high-fired alumina, silicon carbide (reaction bonded and with no free silicon), or zirconia is expected to be a suitably resistant ceramic for the packing.

b Pitting Corrosion
Chloride is known to cause pitting of stainless steels and related alloys in acid and neutral solutions. Normally the vessel is to operate at 113°F at a pH of 3 to 8. Furthermore, the temperature could rise to about 167°F in the case of loss of cooling jacket function. Data from Phull et al (2000) imply that with these conditions, Hastelloy C-22 or equivalent will be needed as a minimum.

Further, if the vessel were filled with process water and left stagnant, there would be a tendency to pit. The time to initiate would depend on the source of the water, being shorter for filtered river water and longer for DIW. Pitting has been observed in both cases, and is likely because residual chlorides are likely to remain. Pitting is less likely for the higher alloys such as C-22.

Conclusion:
Hastelloy C-22 or equivalent is recommended.

c End Grain Corrosion
End grain corrosion only occurs in concentrated acid conditions.

Conclusion:
Not believed likely in this system.

d Stress Corrosion Cracking
The exact amount of chloride required to cause stress corrosion cracking is unknown. In part this is because the amount varies with temperature, metal sensitization, the environment, and because chloride tends to concentrate under heat transfer conditions, by evaporation, and electrochemically during a corrosion process. Hence, even as little as 10 ppm can lead to cracking under some conditions. For the proposed conditions, Hastelloy C-22 or equivalent is required because of its greater resistance to SCC.

Conclusion:
Because of the normal operating environment as well as that which can occur during off normal conditions, the minimum alloy recommended is Hastelloy C-22.

e Crevice Corrosion
See Pitting.

Conclusion:
See Pitting

f Corrosion at Welds
It is expected that the heat tint will be removed during normal operation.

Conclusion:
Weld corrosion is not considered a problem for this system.

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g Microbiologically Induced Corrosion (MIC)
The proposed operating conditions are not conducive to microbial growth. The system is downstream of the main entry points of microbes and the air streams are heated to over 500°F.

Conclusion:
MIC is not considered a problem.

h Fatigue/Corrosion Fatigue
Corrosion fatigue is not expected to be a concern. The pressures encountered are so low and the strength of the material is so comparatively high that corrosion fatigue is not a problem.

Conclusions
Should not be a concern.

i Vapor Phase Corrosion
The vapor phase portion of the vessel is expected to be contacted with particles of waste from splashing. It is expected the region will be sufficiently washed to prevent solids deposits.

Conclusion:
Vapor phase corrosion is not believed to be of concern.

j Erosion
Velocities within the vessel are expected to be low. Erosion allowance of 0.004 inch for components with low solids content (< 2 wt%) at low velocities is based on 24590-WTP-RPT-M-04-0008.

Conclusion:
Not believed to be of concern.

k Galling of Moving Surfaces
Not applicable.

Conclusion:
Not applicable.

l Fretting/Wear
No metal/metal contacting surfaces expected.

Conclusion:
Not believed to be of concern.

m Galvanic Corrosion
No dissimilar metals are present.

Conclusion:
Not believed to be of concern.

n Cavitation
None expected.

Conclusion:
Not believed to be of concern.

o Creep
The temperatures are too low to be a concern.

Conclusion:
Not applicable.

p Inadvertent Nitric Acid Addition
At this time, the design does not provide for the presence of nitric acid reagent in this system. Additionally, the scrubbers see low pH under normal operating conditions.

Conclusion:
Not applicable.

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References:

1. 24590-WTP-RPT-M-04-0008, Rev. 2, *Evaluation Of Stainless Steel Wear Rates In WTP Waste Streams At Low Velocities*
2. 24590-WTP-RPT-PR-04-0001, Rev. B, *WTP Process Corrosion Data*
3. Clark, DE & BK Zoitos (Editors), 1992, *Corrosion of Glass, Ceramics and Ceramic Superconductors*, Noyes Publications, Park Ridge, NJ 07656
4. Phull, BS, WL Mathay, & RW Ross, 2000, *Corrosion Resistance of Duplex and 4-6% Mo-Containing Stainless Steels in FGD Scrubber Absorber Slurry Environments*, Presented at Corrosion 2000, Orlando, FL, March 26-31, 2000, NACE International, Houston TX 77218.
5. Sedriks, AJ, 1996, *Corrosion of Stainless Steels*, John Wiley & Sons, Inc., New York, NY 10158
6. Wilding, MW and BE Paige, 1976, *Survey on Corrosion of Metals and Alloys in Solutions Containing Nitric Acid*, ICP-1107, Idaho National Engineering Laboratory, Idaho Falls, ID

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1. Agarwal, DC, *Nickel and Nickel Alloys*, In: Revie, WW, 2000. *Uhlig's Corrosion Handbook*, 2nd Edition, Wiley-Interscience, New York, NY 10158
2. Berhardsson, S, R Mellstrom, and J Oredsson, 1981, *Properties of Two Highly corrosion Resistant Duplex Stainless Steels*, Paper 124, presented at Corrosion 81, NACE International, Houston, TX 77218
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6. Hamner, NE, 1981, *Corrosion Data Survey*, Metals Section, 5th Ed, NACE International, Houston, TX 77218
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9. Uhlig, HH, 1948, *Corrosion Handbook*, John Wiley & Sons, New York, NY 10158
10. Van Delinder, LS (Ed), 1984, *Corrosion Basics*, NACE International, Houston, TX 77084

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24590-WTP-RPT-PR-04-0001, Rev. B
WTP Process Corrosion Data

PROCESS CORROSION DATA SHEET

Component(s) (Name/ID #) SBS and SBS condensate collection vessels (LOP-VSL-00001, LOP-VSL-00002, LOP-SCB-00001, LOP-SCB-00002)

Facility LAW

In Black Cell? No

Chemicals	Unit[1]	Contract Maximum		Non-Routine		Notes
		Leach	No leach	Leach	No Leach	
Aluminum	g/l	5.07E-02	5.12E-02			
Chloride	g/l	1.22E+01	1.35E+01			
Fluoride	g/l	2.61E+00	2.88E+00			
Iron	g/l	2.62E-02	2.54E-02			
Nitrate	g/l	5.85E-02	6.60E-02			
Nitrite	g/l					
Phosphate	g/l					
Sulfate	g/l					
Mercury	g/l	9.93E-01	3.45E-02			
Carbonate	g/l					
Undissolved solids	wt%	1.4%	1.3%			
Other (Pb)	g/l	6.11E-03	3.85E-04			
Other	g/l					
pH	N/A					Note 2
Temperature (note 2)	°F					Note 3

List of Organic Species:

References

System Description: 24590-LAW-3YD-LOP-00001, Rev 0
Mass Balance Document: 24590-WTP-M4C-V11T-00005, Rev A
Normal Input Stream #: LOP01, LOP04
Off Normal Input Stream # (e.g., overflow from other vessels):
P&ID: 24590-LAW-M6-LOP-P0001, 24590-LAW-M6-LOP-P0002, Rev 1
PFD: 24590-LAW-M5-V17T-P0007, -P0008, Rev 0
Technical Reports: N/A

Notes:

1. Concentrations less than 1x 10^{-4} g/l do not need to be reported; list values to two significant digits max.
2. pH 3 to 8 (CCN 025050)
3. Tmin 41, T nominal 113 °F. If loss of cooling jacket function assume 167 °F (24590-LAW-MVC-LOP-00001, Rev B)

Assumptions:

24590-WTP-RPT-PR-04-0001, Rev. B
WTP Process Corrosion Data

6.3.1 SBS and SBS Condensate Vessels (LOP-SCB-00001,2 and LOP-VSL-00001,2)

Routine Operations

Offgas from the film cooler flows through the offgas line then enters the SBS column, which is enclosed in the SBS column vessel (LOP-SCB-00001/2) for further cooling and solids removal. Each melter has a dedicated SBS. The SBS is a passive device designed for aqueous scrubbing of entrained radioactive particulate from melter offgas plus cooling and condensation of melter vapor emissions.

The SBS has two offgas inlets, one for the normal operations line and one for the standby line. The inlet pipes run down through the bed to the packing support plate. The bed-retaining walls extend below the support plate, creating a lower skirt to prevent gas from bypassing the packing. A hold-down screen is used to prevent the bed from being carried out by upward flow through the bed. Gas bubbles are formed as the gas passes through holes in the support plate. The bubbles rise through the packed bed and cause the liquid to circulate up through the packing, and hence downward in the annular space outside the packed bed. The packing breaks larger bubbles into smaller ones to increase the gas-to-water contact area and helps increase the particulate removal and heat transfer efficiencies.

The scrubbed offgas discharges through the top of the SBS. The liquid circulation helps to prevent buildup of captured material in the bed by constantly washing the material away. A cooling jacket located on the outside of the scrubber vessel and cooling coils located inside the vessel maintain the scrubbing liquid at required temperatures.

As the offgas cools, water vapor condenses and increases the liquid inventory. The liquid overflows into the SBS condensate vessel (LOP-VSL-00001/2) located next to the SBS column vessel, thereby maintaining a constant liquid depth in the SBS column vessel. The SBS condensate vessel has a cooling jacket to further cool the condensate. This cooled condensate, when recycled (pumps LOP-PMP-00001/4) to the SBS column vessel, contributes to the cooling of the SBS condensate and keeps collected solids mobilized for removal. The condensate vessel has the capacity to hold about 2 days of condensate. Venting of this vessel is via the SBS column vessel into the main offgas discharge pipe.

To help remove solids, the recirculated stream is pumped through eight lances that agitate the bottom of the SBS column vessel and consolidate the solids near the pump suction. To suspend the solids accumulated in the SBS condensate vessel, an eductor is used, powered by a side stream from the recirculation line.

Condensate produced and solids captured in the SBS column vessels are removed periodically.

Non-Routine Operations that Could Affect Corrosion/Erosion

- Both the SBS and SBS condensate vessels contain spray nozzles that are used during startup to fill the vessels and for decontamination. If maintenance of the offgas line, SBS, or WESP is required during the lifetime of the melter, a maintenance bypass line is provided from the standby offgas line in the wet process cell to the standby line on the other melter. The other melter must be idled for this to occur since the standby line must be open to the SBS, but none of the treatment steps are bypassed.
- **Solids buildup in SBS bed** - This may cause the offgas to bypass the bed with reduced quenching and decontamination. Higher pressure differential indicates a buildup. Depending on the reduction of function, the maintenance bypass is activated and the SBS is flushed out, the bed is fluidized by increasing offgas flow, or the bed is replaced at the next melter changeout.

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- **Chilled water failure in the SBS** - If the chilled water flow to the SBS fails, the scrubbing solution temperature begins to increase. If the chilled water flow is not restored in a reasonable period, the solution temperature rises and liquid begins to evaporate. The equilibrium temperature reached is about 165 °F (74 °C). Demineralized water is added to either the SBS column or the condensate vessel via the wash header to compensate for water evaporated.
- **Solids buildup in SBS** - This results in reduced liquid flow through the bed, with reduced quenching and decontamination. A higher offgas temperature indicates this problem. Depending on the reduction of function, the melter is idled, the maintenance bypass opened, and the SBS isolated and flushed out. If the problem is not severe, the corrective action may be deferred until the next melter changeout.
- **Loss of SBS pump** - Loss of the SBS water purge pump (LOP-PMP-00003A/6A) interrupts the periodic transfer from the SBS column vessel to the SBS condensate collection vessel. Pump LOP-PMP-00003B/6B acts as a backup and periodically pumps accumulated condensate to the SBS condensate collection vessel until the failed pump is replaced. The spare pump in the SBS condensate vessel (LOP-PMP-00002/5) can also be used to transfer liquid from the system to the SBS condensate collection vessel.
- **Loss of SBS condensate vessel pump** - The SBS condensate vessel has two pumps that have the capability of either recirculating condensate to the SBS or pumping it to the SBS condensate collection vessel. If one fails, the other one acts as a backup until the failed pump is replaced.
- **Loss of eductor in the SBS condensate vessel** - If the eductor fails, the melter is idled, the maintenance bypass is activated, and the offgas line is isolated by closing the isolation valve downstream of the WESP. The eductor is then replaced.